CLAIMS

1. (amended) A method for increasing the speed of line-by-line calculations of multiple overlapping absorption lines, said method comprising:

(1) a step of dividing a domain of a Voigt function representing the shape of an absorption line into a first range around the peak of the Voigt function and a skirt portion not contained in the first range, replacing the first range with a cubic function whose function values and derivative values match with those of said Voigt function at the connection points with said Voigt function, and calculating the values and derivative values of said cubic function and the Voigt function in the skirt portion for each of first predetermined intervals;

(2) a step of adding together the results of step (1) for a plurality of absorption lines;

(3) a step of interpolating the results of step (2) to calculate the function values and derivative values in second predetermined intervals smaller than said first predetermined intervals;

(4) a step of dividing said first range into a second range near the peak and a skirt portion not contained in the second range, replacing said second range of a "function representing the difference between the Voigt function and said cubic function" with a second cubic function whose function values and derivative values match with those of said "function representing the difference between the Voigt function and said cubic function" at the connection points with said "function representing the difference between the Voigt function and said cubic function", and calculating the values and derivative values of said second cubic function replacing said second range and the "function representing the difference between the Voigt function and said second cubic function" in the skirt portion for said second predetermined intervals;

(5) a step of adding the results of step (4) to the results of step (3) for a plurality of absorption lines;

(6) a step of interpolating the results of step (5) to calculate the function values and derivative values for intervals smaller than said second predetermined intervals; and

(7) a step of adding the values of the "function representing the difference between the Voigt function and said second cubic function" to the results of step (6) for a plurality of absorption lines in said second range.

2. (amended) A method in accordance with claim 1, wherein (8) the step of calculating function values and derivative values by interpolation is repeated while narrowing the interval until it becomes an interval of a minimum unit.

3. (amended) A method in accordance with claim 1, wherein said steps (4) through (6) are repeated one or more times until the "intervals smaller than said second predetermined intervals" in step (6) reach third predetermined intervals.

4. (amended) A method in accordance with claim 1, wherein said predetermined interval is determined by using the following equation.

Said first predetermined intervals are $j^{kmax}dv$. Here, j is a single-digit natural number, dv is the increment in wave number, and $kmax$ is the largest natural number satisfying the relationship $j^{kmax+2}pdv \leq Vmax$, where $Vmax$ represents the maximum calculation range from the center of the absorption line, and p is a natural number for controlling the calculation precision.

5. (amended) A method in accordance with claim 3, wherein said predetermined interval is determined using the following equation.

The third predetermined intervals are $j^{kmin}dv$. Here, j is a single-digit natural

number, dv is the increment of the wave number, and $kmin$ is the maximum non-negative decimal number satisfying the relationship $j^{kmin}pdv \leq \alpha$ (α being approximately $\gamma/4$) where γ is an approximate value of the full-width at half-maximum of the absorption line, and p is a natural number for controlling the calculation precision.

6. (amended) A method in accordance with claim 1, wherein said second predetermined interval is determined by using the following equation.

For the sub-function with the $(k - kmin + 1)$-th smallest width, the predetermined interval is $j^k dv$. Here, j is a single-digit natural number, dv is the increase in wave number and k is such that $kmin \leq k < kmax$. $kmax$ is a natural number satisfying the relationship $j^{kmax+2}pdv \leq Vmax$, where $Vmax$ represents the maximum calculation range from the center of the absorption line, and p is a natural number for controlling the calculation precision. $kmin$ is the maximum non-negative decimal number satisfying the relationship $j^{kmin}pdv \leq \alpha$ (α being approximately $\gamma/4$), where γ is an approximate value of the full-width at half-maximum of the absorption line, and p is a natural number for controlling the calculation precision.

7. (amended) A method in accordance with any one of claims 1-3, wherein said interpolation is calculated by quartering the interpolation interval, with the function values represented by y_a, y_b, y_c and the derivative values represented by y_a', y_b', y_c' at the points where the interpolation interval (x_0, x_1) is divided, using the function values y_0, y_1 and function derivative values y_0', y_1' at x_0, x_1, with the below-given Equation (1) as a function value interpolation equation, Equation (2) as a function derivative value interpolation equation and ε as a non-negative decimal fraction.

$$\begin{pmatrix} y_a \\ y_b \\ y_c \end{pmatrix} = \frac{1}{64}\begin{pmatrix} 54-6\varepsilon & 10+6\varepsilon & 9(1-\varepsilon) & -3(1-\varepsilon) \\ 32 & 32 & 8(1-\varepsilon) & -8(1-\varepsilon) \\ 10+6\varepsilon & 54-6\varepsilon & 3(1-\varepsilon) & -9(1-\varepsilon) \end{pmatrix}\begin{pmatrix} y_0 \\ y_1 \\ (x_1-x_0)y'_0 \\ (x_1-x_0)y'_1 \end{pmatrix} \quad (1)$$

$$\begin{pmatrix} y'_a \\ y'_b \\ y'_c \end{pmatrix} = \frac{1}{16(x_1-x_0)}\begin{pmatrix} -18+2\varepsilon & 18-2\varepsilon & 3(1-\varepsilon) & -5(1-\varepsilon) \\ -24+8\varepsilon & 24-8\varepsilon & -4(1-\varepsilon) & -4(1-\varepsilon) \\ -18+2\varepsilon & 18-2\varepsilon & -5(1-\varepsilon) & 3(1-\varepsilon) \end{pmatrix}\begin{pmatrix} y_0 \\ y_1 \\ (x_1-x_0)y'_0 \\ (x_1-x_0)y'_1 \end{pmatrix} \quad (2)$$

8. (amended) A method in accordance with any one of claims 1-3, wherein said interpolation is calculated by dividing the interpolation interval into five parts, with the function values represented by y_a, y_b, y_c, y_d and the derivative values represented by y_a', y_b', y_c', y_d' at the points where the interpolation interval (x_0, x_1) is divided, using the function values y_0, y_1 and function derivative values y_0', y_1' at x_0, x_1, with the below-given Equation (3) as a function value interpolation equation, Equation (4) as a function derivative value interpolation equation and ε as a non-negative decimal fraction.

$$\begin{pmatrix} y_a \\ y_b \\ y_c \\ y_d \end{pmatrix} = \frac{1}{125}\begin{pmatrix} 112-12\varepsilon & 13+12\varepsilon & 16(1-\varepsilon) & -4(1-\varepsilon) \\ 81-6\varepsilon & 44+6\varepsilon & 18(1-\varepsilon) & -12(1-\varepsilon) \\ 44+6\varepsilon & 81-6\varepsilon & 12(1-\varepsilon) & -18(1-\varepsilon) \\ 13+12\varepsilon & 112-12\varepsilon & 4(1-\varepsilon) & -16(1-\varepsilon) \end{pmatrix}\begin{pmatrix} y_0 \\ y_1 \\ (x_1-x_0)y'_0 \\ (x_1-x_0)y'_1 \end{pmatrix} \quad (3)$$

$$\begin{pmatrix} y'_a \\ y'_b \\ y'_c \\ y'_d \end{pmatrix} = \frac{1}{25(x_1-x_0)}\begin{pmatrix} -24-\varepsilon & 24+\varepsilon & 8(1-\varepsilon) & -7(1-\varepsilon) \\ -36+11\varepsilon & 36-11\varepsilon & -3(1-\varepsilon) & -8(1-\varepsilon) \\ -36+11\varepsilon & 36-11\varepsilon & -8(1-\varepsilon) & -3(1-\varepsilon) \\ -24-\varepsilon & 24+\varepsilon & -7(1-\varepsilon) & 8(1-\varepsilon) \end{pmatrix}\begin{pmatrix} y_0 \\ y_1 \\ (x_1-x_0)y'_0 \\ (x_1-x_0)y'_1 \end{pmatrix} \quad (4)$$

9. (amended) A method in accordance with any one of claims 1-8, for increasing the speed of line-by-line calculations, when assuming the Voigt function to be $K(x, y)$ and the shape of the absorption line displaced from the Voigt profile of the absorption line to be $K(x, y) + f(x)$, by replacing

$$K(x,y)$$

with:

$$\widetilde{K}(x,y) = AK(x,y) + Bf(x)$$

and

$$\frac{\partial K(x,y)}{\partial x}$$

with

$$\frac{\partial \widetilde{K}(x,y)}{\partial x} = A\frac{\partial K(x,y)}{\partial x} + B\frac{\partial f(x)}{\partial x}$$

10. (amended) A method in accordance with any one of claims 1-8, for increasing the speed of line-by-line calculations, when assuming the Voigt function to be $K(x, y)$ and the shape of the absorption line displaced from the Voigt profile to be $K(x, y)f(x)$, by replacing

$$K(x,y)$$

with:

$$\widetilde{K}(x,y) = K(x,y)f(x)$$

and

$$\frac{\partial K(x,y)}{\partial x}$$

with

$$\frac{\partial \widetilde{K}(x,y)}{\partial x} = \frac{\partial K(x,y)}{\partial x}f(x) + K(x,y)\frac{\partial f(x)}{\partial x}$$

11. (amended) A method in claim 10, for increasing the speed of line-by-line calculations, by using, in a sub-Lorentzian correction,

$$\widetilde{K}(x,y) = K(x,y)A\exp(-B|x|)$$

and

$$\frac{\partial \widetilde{K}(x,y)}{\partial x} = \frac{\partial K(x,y)}{\partial x} A\exp(-B|x|) + K(x,y)[-\operatorname{sgn}(x)AB\exp(-B|x|)]$$

12. (amended) A method in accordance with claim 9, for increasing the speed of line-by-line calculations, by replacing, in a line-mixing correction,

$$K(x,y)$$

with:

$$\widetilde{K}(x,y) = AK(x,y) + BL(x,y)$$

and

$$\frac{\partial K(x,y)}{\partial x}$$

with

$$\frac{\partial \widetilde{K}(x,y)}{\partial x} = -2\left[(Ax+By)K(x,y) - (Ay-Bx)L(x,y) - \frac{B}{\sqrt{\pi}}\right]$$

Here, $L(x, y)$ is the imaginary component of the function $w(z)$ (the real part is the Voigt function), where complex number $z = x + iy$, defined by the following equation.

$$w(z) = \frac{i}{\pi}\int_{-\infty}^{\infty}\frac{\exp(-t^2)}{z-t}dt = \exp(-z^2)erfc(-iz) = K(x,y) + iL(x,y)$$

($erfc(z)$ is a complex complementary error function).

13. (amended) A program for increasing the speed of line-by-line calculations of multiple overlapping absorption lines, said program comprising:

(1) a step of dividing a domain of a Voigt function representing the shape of an absorption line into a first range around the peak of the Voigt function and a skirt portion not contained in the first range, replacing the first range with a cubic function

whose function values and derivative values match with those of said Voigt function at the connection points with said Voigt function, and calculating the values and derivative values of said cubic function and the Voigt function in the skirt portion for each of first predetermined intervals;

(2) a step of adding together the results of step (1) for a plurality of absorption lines;

(3) a step of interpolating the results of step (2) to calculate the function values and derivative values in second predetermined intervals smaller than said first predetermined intervals;

(4) a step of dividing said first range into a second range near the peak and a skirt portion not contained in the second range, replacing said second range of a "function representing the difference between the Voigt function and said cubic function" with a second cubic function whose function values and derivative values match with those of said "function representing the difference between the Voigt function and said cubic function" at the connection points with said "function representing the difference between the Voigt function and said cubic function", and calculating the values and derivative values of said second cubic function replacing said second range and the "function representing the difference between the Voigt function and said second cubic function" in the skirt portion for said second predetermined intervals;

(5) a step of adding the results of step (4) to the results of step (3) for a plurality of absorption lines;

(6) a step of interpolating the results of step (5) to calculate the function values and derivative values for intervals smaller than said second predetermined intervals; and

(7) a step of adding the values of the "function representing the difference between the Voigt function and said second cubic function" to the results of step (6) for a plurality of absorption lines in said second range.

14. (amended) A program in accordance with claim 13, wherein the step of calculating function values and derivative values by interpolation is repeated while narrowing the interval until it becomes an interval of a minimum unit.

15. (amended) A program in accordance with claim 13, wherein said steps (4) through (6) are repeated one or more times until the "intervals smaller than said second predetermined intervals" in step (6) reach third predetermined intervals.